SPATIAL AND TEMPORAL VARIABILITY OF DISCARDS INDICATORS AND FISHERY FACTORS AFFECTING OTTER-TRAWL FISHERY IN THE SPANISH MEDITERRANEAN SEA

Carbonell A., Rubio V., Mir A., García T., Olafsson E., Torres P., Guijarro B., Pérez N., Valeiras X., and Bellido J. M.

Instituto Español de Oceanografía
Corresponding author ana.carbonell@ba.ieo.es

Introduction

In the Mediterranean and in the western area where the Spanish demersal fisheries are located, discards of the coastal zone is around 50% and in certain areas exceeds this percentage, while in deep fishery total discard is considerably lower and around 20% (Carbonell and Mallol, *in press*).

Evaluation of Spanish Mediterranean trawling indicates that discard rates of target species are close to zero. But estimation of the total discard rates is considerably high. The discrepancy between target species and total discard rates lies in the fact that discard is comprised by invertebrate species and fish with low commercial value. These are benthic and semi-pelagic species caught with the target species.

On board sampling data information of the fishery is directly related to fishing strategy and is useful for analyzing their trend (Essington, 2010). We use the time series to assess the fishing impact**.** For that we need indicators easily applicable by fishery managers. Ideally such indicators should reveal damage or worsening in the ecosystem status. The fishing impact effect has to be measurable and has to have a clear direction of change and/or an optimum value (Trenkel and Rochet, 2003).

1. Time series analysis and Ecological Impact Indicators

Table 1. Species of Ecological Impact Groups (EIG) indicators of fishing stress for the coastal fishery.

Impact Indicator	Species	Ecological traits
EIG 1	*Astropecten aranciacus*	low vulnerability
EIG 2	*Echinaster sepositus*	low vulnerability
Spatangus purpureus	*Sphaerechinus granularis*	
EIG 3	*Aplidium conicum*	high vulnerability
Diazona violacea	*Ascidia mentula*	
	Microcosmus vulgaris	
EIG 4	*Axinella damicornis*	high vulnerability
	Tethya aurantium	

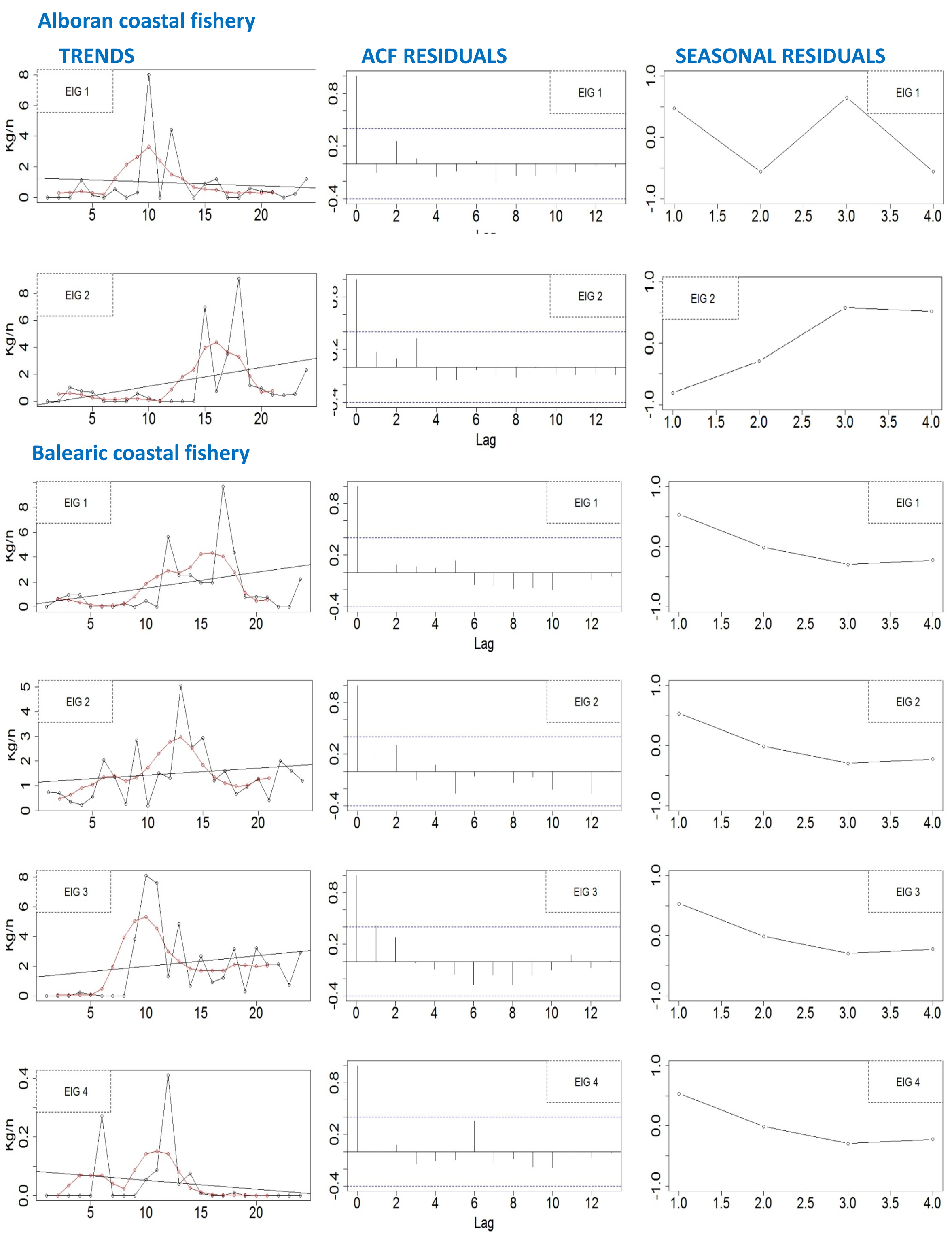


Table 2. Species of Ecological Impact Groups (EIG) indicators of fishing stress for the deep fishery.

EIG 3	*Alcyonium palmatum*	High vulnerability
Alcyonium palmatum	*Microcosmus vulgaris*	
Aplidium conicum	*Microcosmus vulgaris*	
EIG 4	*Axinella damicornis*	High vulnerability
Aristaeomorpha foliacea	*Tethya aurantium*	
Chimaera monstrosa	*Paramola cuvieri*	

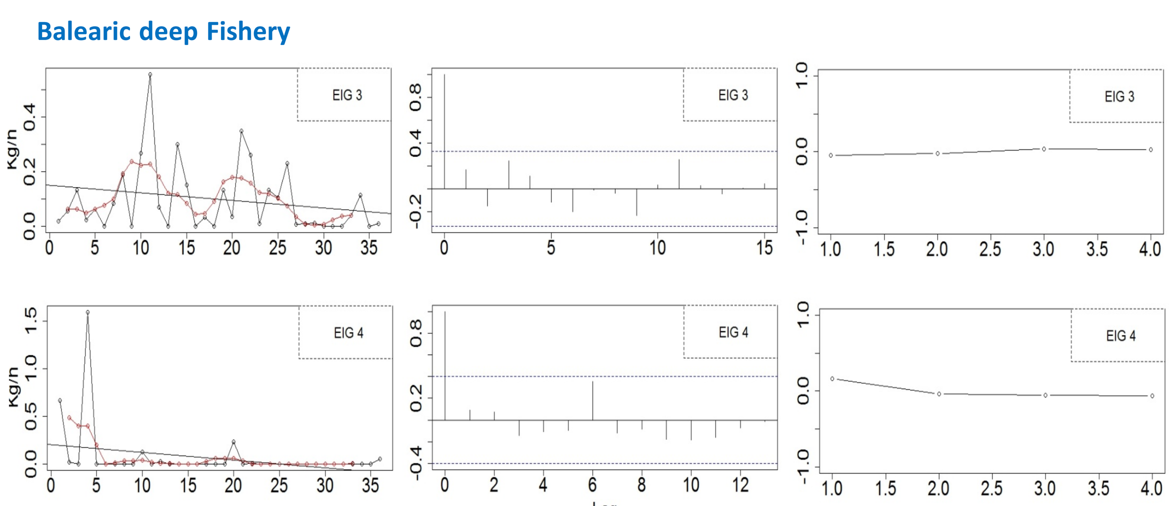
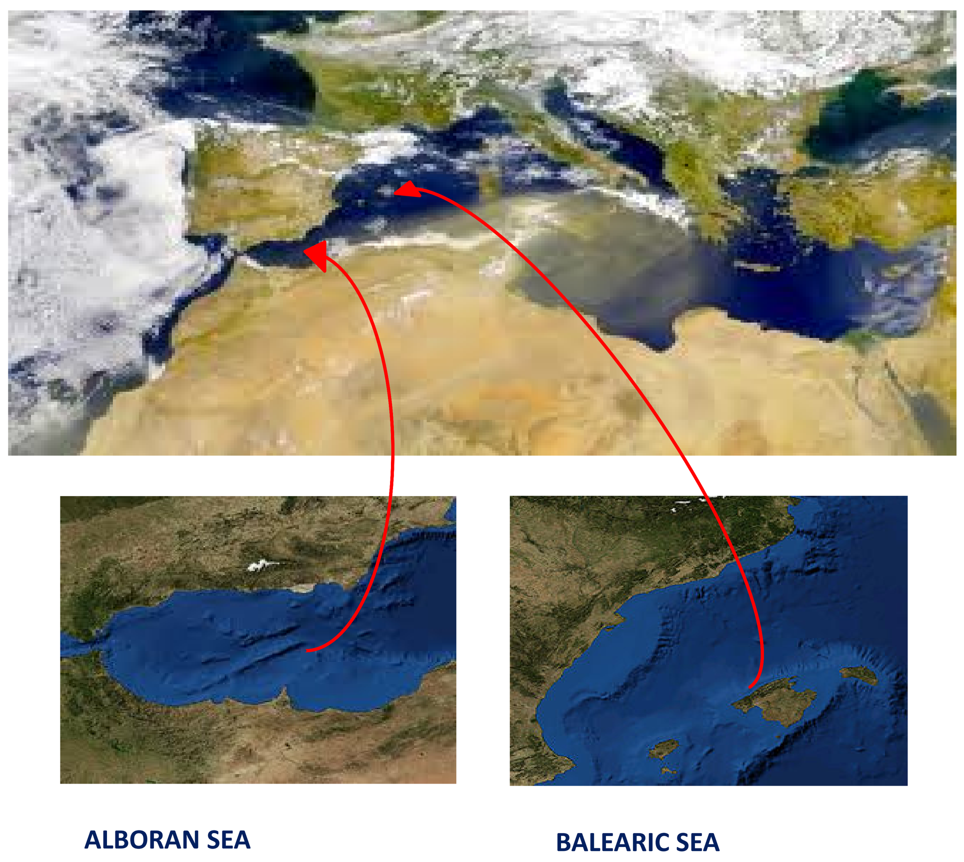


Figure 2. For each time series moving average (MA(4)) of four points, corresponding to the four seasons, was done to smooth the time series. The MA model provided the most straightforward way to account for serial dependency of the data and to model changes in the mean through time. Discard EIGs series showed positive linear relationship with total biomass, implying that increases in total biomass lead increases in discards for EIGs 1, 2, and/or 3, 4, but they were note significant relationship over time for the coastal fishery and significant for the deep fishery, none significant linear autocorrelation (ACF) at any lag between x_t and x_{t-h} was found. Periodic signals in time series for each EIG exhibit slightly years cycles. Ecological Impact Indicators of low (EIG 1 and 2) and high (EIG 3 and 4) fishing vulnerability showed three different situations: 1) high variability in biomass for low vulnerability indicators in the Alboran coastal fishery, 2) increasing biomass of low vulnerability indicators in periods of decreasing trend in captures in the Balearic coastal fishery, and 3) decreasing trend of high vulnerability groups in the deep Balearic fishery.



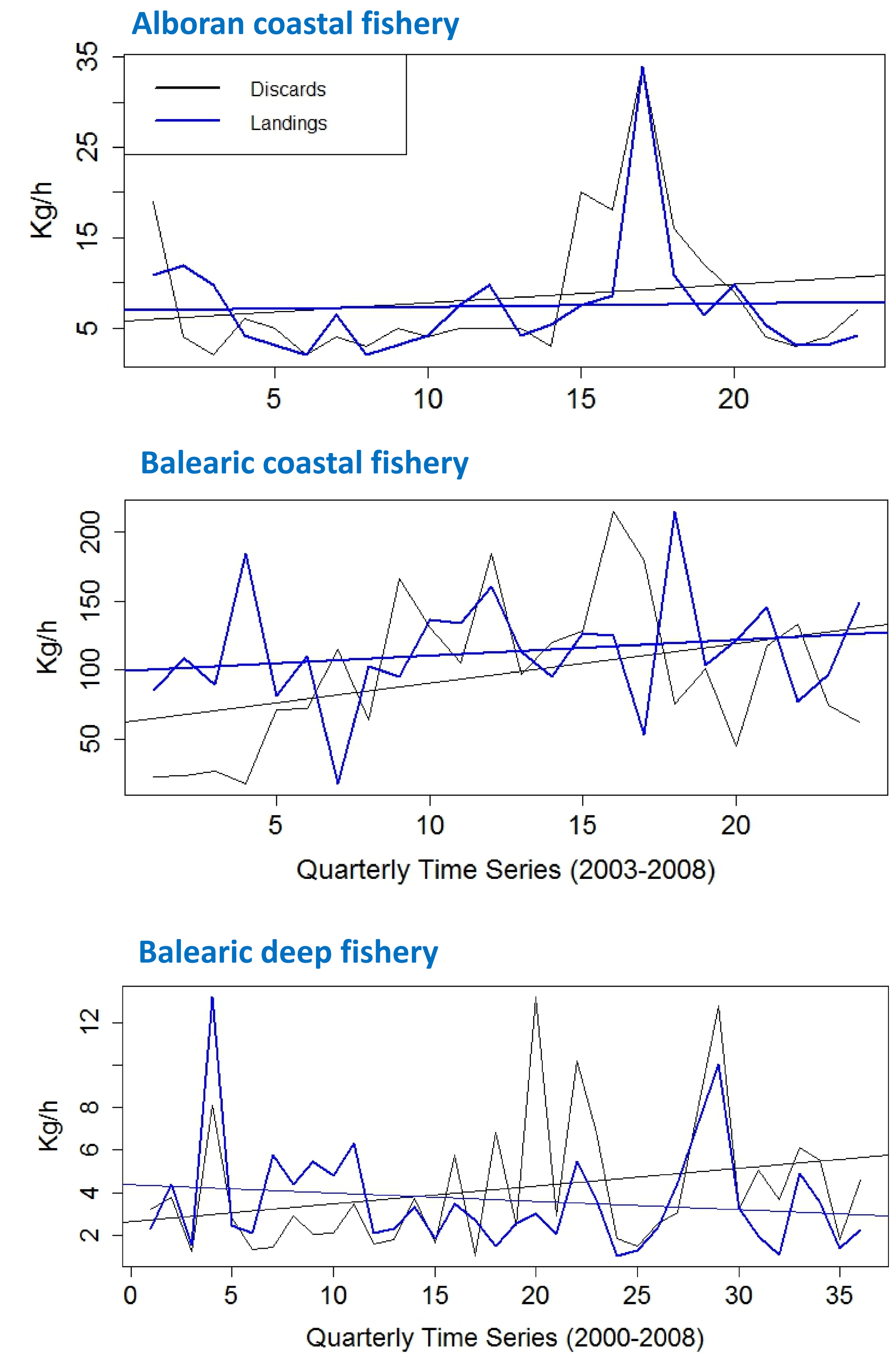


Figure 1. Quarterly time series for each fishery on landing and discard. Trends of the time series data showed three different situations: 1) slight increasing trend landing but steady state of discard in the Alboran coastal fishery, 2) increasing trend for both landing and discard in the Balearic coastal fishery, and 3) slightly increasing trend for landing and decreasing trend for discard in the Balearic deep fishery.

Discussion and Conclusions

1) Time series did not show any regularity. Different situations of discards and landing were found in each fishery. Therefore management predictions should be done carefully for short time periods. The time series studied did not present significant fluctuations. The upward trends of the coastal fishery could be related to the fishing efficiency and also to the spatial behavior of the fleet. The deep fishery showed a slow, steady decline of the trend of discards, which is related to the lost of species sensitive to the fishing.

2) Ecological impact indicators showed adequate traits to assess the trawling impacts intensity throughout the fishery time series, although the information that we got from some of these indicators was not always reliable. For instance, indicators 3 and 4 in the Alboran coastal fishery, and 1 and 2 in the Balearic deep fishery, were not used because they showed inconsistencies.

3) Effect Sizes could be used as the reference point to assess fishing impact and for management assessment plans. But the characteristic of high heterogeneity of the data was the cause of non significant cumulative response of the ration. The biodiversity declining trends for species richness and for the other biodiversity indices implied deterioration throughout the time in the quality of habitats and populations. On average, the effect sizes decreased of one point in the coastal fishery, and about half point in the deep fishery.

Questions and Objective

1) Do the time series of data obtained on board sampling have any regularity which can be used for management predictions?

2) Can we use the impact Indicators created in experimental studies for the analysis of series of data obtained on board sampling?

3) Using statistical methods such as "Effect Sizes", Is it possible to establish reference point to limit and avoid the fishing damage?

The main question is: How can we regulate the fishing to avoid the irreversible damage of fishing grounds? The goal of the present study was to estimate the effect of fishing impact to provide basis for their future regulation.

Methods

We selected groups of species in each fishery that were grouped according to their characteristics in relation to its ability to demonstrate the fishing impact (Juan and Demestre, 2012). The captures (landings and discards), and Indicators (EIGs) were estimated in biomass standardized in kilograms per hour (kg/h).

1) An exploratory analysis of the time series in their seasonal and inter-annual components trends was studied by simple lineal regression.

2) To measure global ecosystems quality, we studied the time series of biodiversity indices: Richnnes (S), Simpson (1-λ), and Shannon-Wiener (Loge(H)).

3) To quantify the fishing impact we converted the Impact Indicators groups in a single estimator (de Juan and Demestre, 2012), the Trawling Disturbance Index (TDI). Using this TDI index, the effect response of the time series mean and variance biomass was estimated by the ratio estimator of the current time series and a control TDI (Hedges and Olkin. 1985). This control data were obtained from the initial Western Mediterranean study (Carbonell, 1997) during the nineties.

2. Ecosystem quality status : Diversity Time series indices

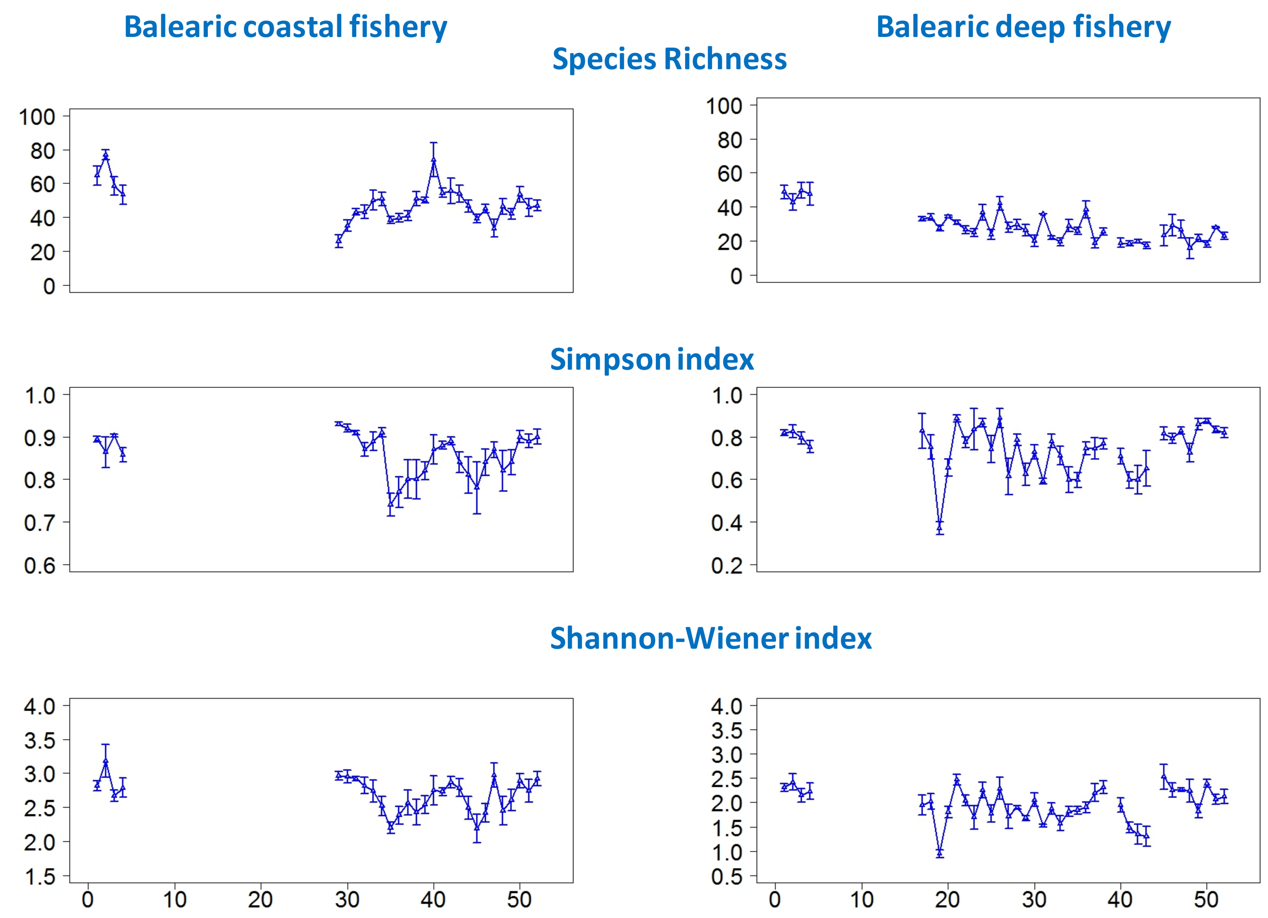


Figure 3. Quarterly time series diversity indices for the Balearic fisheries: 1) Species richness decreases throughout the time for both fisheries, 2) Evenness diversity (Simpson index =1-λ) measures the situations when an impoverishment of both species and biomasses occurs on the time series, and also its recovery and 3) Heterogeneity diversity (Shannon-Wiener index= $Log_e(H)$) followed similar trend to evenness. Both indices showed a decrease from the values of the reference control series (1994-1996). Multivariate analysis of nMDS ordination for biodiversity per year (figures not shown) showed none significant differences in the MDS ordination per year (with a percentage of similarity between 70 and 95%) for both fisheries.

3. Fishing Impact: Effect Sizes

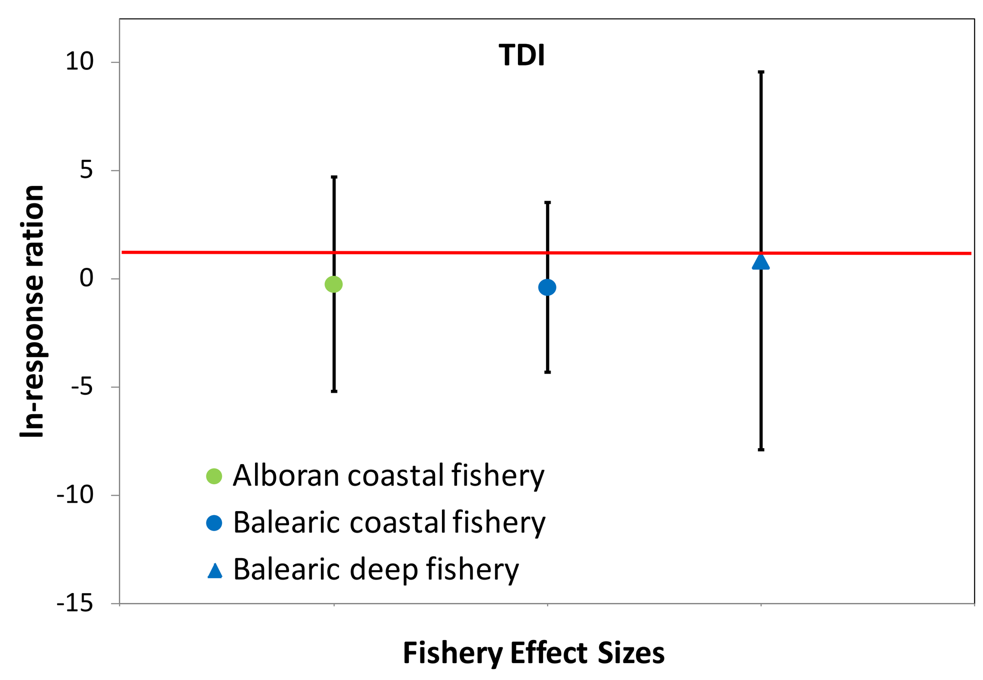


Figure 4. Cumulative impact of fishing (ln- response ration); mean and ±95% confidence intervals. Cumulative effects were not significant since confidence intervals overlap zero. Effect Size of the Alboran coastal fishery was between -0.8 and 0.4 (Q_T= 0.94, p>0.05, df=23), for the Balearic coastal fishery -1 and 0 (Q_T= 0.92, p>0.05, df=23), and the deep fishery 0.7 and 1.2 (Q_T= 0.079, p>0.05, df=35).

References:

Carbonell, A. 1997. Discards of the Western Mediterranean Trawl fleets. UE_CEE_DGXIV. Study nº94-027.

Carbonell, A., S. Mallol. Differences between demersal fisheries discards: high and low productivity zones of the Northwestern Mediterranean Sea. *Boll. Soc. Hist. Nat*. Balears, 55:141-155.(*in press*).

Essington, T. E. 2010. Ecological indicators display reduced variation in North American catch share fisheries. PNAS January 12, 2010 vol. 107 no. 2: 754-759.

de Juan, S., M. Demestre. 2012. A Trawl Disturbance Indicator to quantify large scale fishing impact on benthic ecosystems. *Ecological Indicators*, 18:183-190.

Hedges, L. V., I. Olkin. 1985. *Statiscal Methods for Meta-Analysis*. Academic Press, New York, USA.

Trenkel, V. M., M.-J. Rochet. 2003. Performance of indicators derived from abundance estimates for detecting the impact of fishing on a fish community. *Canadian Journal of Fisheries and Aquatic Sciences,* 60(1): 67-85.

Acknowledgments
This work was undertaken as part of the BADMINTON-MariFish PROJECT FP 6 funding Framework. The authors thank the project for the support provided to develop this work.